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(54) Title: LEAD-FREE FRANGIBLE PROJECTILE

(57) Abstract

Frangible projectiles free of heavy metals suitable for use in indoor target ranges comprising tungsten and at least one metal selec from the group consisting of iron and copper. The projectiles are prepared from a mixture of tungsten and iron powders, tungsten : copper powders, or tungsten, iron and copper powders and compacted without sintering.

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LEAD-FREE FRANGIBLE PROJECTILE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on provisional Application No. 60/011,053P.

BACKGROUND OF THE INVENTION

This invention relates generally to ammunition and more particularly to frangible target ammunition, training ammunition, or sporting ammunition.

A need exists for training ammunition that can be used in indoor target ranges. Such ammunition must be frangible to reduce or eliminate the potential for ricochet. A frangible bullet, upon impact with its target, will disintegrate with no appreciable back splatter or ricochet as to cause bodily injury to the shooter or others. The need for frangible ammunition has previously been satisfied by bullets made substantially of lead.

Lead bullets, while providing the desired frangibility, also produce unwanted health risks. When fired, a lead bullet introduces airborne and residual lead particles into the air, thereby posing a threat to the health of those in the range, including employees of the range. Additionally, the lead particles produced when the bullet disintegrates upon impact with the target pose an environmental problem. The lead particles are expensive to remove, and costly to dispose of due to their toxicity. The natural toxicity of lead has prompted the search for satisfactory substitutes in a wide variety of applications.

SUMMARY OF THE INVENTION

The projectiles of the present invention satisfy the need for frangible lead free projectiles. The projectiles of the present invention closely mimic the performance and ballistic properties of lead projectiles without the

negative health and environmental properties associated with lead and other heavy metal projectiles.

Specifically, the present invention provides lead free projectiles consisting essentially of a compacted, unsintered admixture of metal particles comprising tungsten and at least one metal selected from the group consisting of iron and copper, wherein the admixture is about from 10 to 90% by weight tungsten; wherein the particle size of each metal is about from 25 to 250 microns.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be more fully understood by reference to the following description. Both a process for the preparation of frangible lead free projectiles and the lead free projectiles themselves are described below. Variations and modifications of both the process and the disclosed embodiments of the projectiles can be substituted without departing from the principles of the invention, as will be evident to those skilled in the art.

The lead free projectiles of the present invention consist essentially of compacted, unsintered admixture of metal particles comprising tungsten and at least one metal selected from the group consisting of iron and copper. The amount by weight of tungsten in the admixture is about from 10 to 90%, and preferably about from 20 to 70%. The particle size of each metal is about from 25 to 250 microns, and preferably at least about 100 microns.

The particle size of the metal particles can be determined by a variety of methods, including conventional optical measurement and sifting. A particle size of at least about 150 microns is particularly preferred. Larger particle sizes have been found to provide a desirable balance between integrity of the projectiles before and during firing, and frangibility upon impact with a target. While the relationship between particle size and performance is not fully

understood, it is believed to be a function of the mechanical interlocking of the particles in the compressed, but unsintered, projectiles. This effect is generally more pronounced in larger particles.

The metals used in combination with tungsten are available in the designated particle size, or can be ground to the size required. The copper can be used in its elemental form or as an alloy such as copper 220 or 260.

The projectiles of the present invention include a variety of small arms projectiles such as centerfire ammunition from .17 to .50 caliber, shot pellets from #9 through 00 buck sizes, shotgun slugs from .410 bore to 12 gauge, and rimfire ammunition in .22 caliber.

The projectiles of the invention can further comprise an outer jacket. In one possible embodiment the jacket consists essentially of metal. A wide variety of metals can be used, but the metal is preferably selected from the group consisting of copper, brass, aluminum, and zinc. Copper is particularly preferred. In another embodiment of the invention, the jacket consists essentially of polymeric material. A wide variety of polymeric materials can be used including semi-crystalline or amorphous thermoplastics, or thermosetting resins. Representative thermoplastic polymers which can be used include polyethylenes, polyamides, polycarbonates, and polystyrenes. Representative thermosetting resins which can be used include phenolics, epoxys, and silicones. Of the above polymeric materials, polyethylene is particularly preferred.

The nose of the centerfire and/or rimfire bullets of the present invention can be configured in a wide variety of profiles, including round nose, soft nose, or hollow point. In addition, the projectiles of the present invention can have a full metal jacket. When the projectiles are in the configuration of a bullet, they can include a driving band, or in embodiments with a jacket, the jacket can comprise a driving band. The driving band increases bullet accuracy and reduces bullet dispersion. The driving band also reduces friction between

projectile and barrel, thereby increasing velocity without appreciable pressure increase. Shot pellets of the present invention can be spherical or have an eccentricity which improves or tightens shot dispersion. The shot pellets can optionally be plated by electrochemical methods with metal to increase lubricity and reduce corrosion. The preferred metal is copper. The shot pellets can also be coated with a polymeric material as mentioned above, preferably polyethylene or other linear low density polymeric material. Shotgun slugs will have either a forward biased centroid for pressure stabilization or a rearward biased centroid for spin stabilization. The slugs may utilize a sabot or polymeric coating mentioned above. Preferred polymeric coatings are polyethylene or other low density materials.

The frangible, lead free projectiles of the present invention can be prepared by a process wherein an admixture of tungsten and at least one metal selected from the group consisting of iron and copper is placed in a feeder or hopper. The feeder or hopper dispenses a metered amount into die cavities of a rotary dial press. The material is then compacted either in a single compaction step or in multiple compaction stages with a pressure of about from 50,000 to 120,000 psi. Compacting the admixture at a pressure of about 100,000 psi is preferred. The resultant effective density is in the range of about from 7.0 to 10.5 g/cc.

The range compaction die should be of a near net shape to the final projectile. For centerfire, rimfire, and rearward biased centroid slugs, the preferred compaction force is applied to the base or rear of the projectile. As a result of the compacting process, the resulting bullet is formed with a higher density toward its tail or rear end, and a lower density at its nose or tip. This measured rearward density promotes greater gyroscopic and dynamic stability, thus reducing bullet dispersion, increasing frangibility, and increasing accuracy. For forward biased centroid slugs, the compaction force is applied at the nose of

the projectile. For shot pellets, it is preferred that the compaction forces be applied equally to both hemispheres of the projectile, to ensure the projectile centroid is located at the geometric center of the projectile.

The desired cycle time of the powder compaction and subsequent projectile core formation is from 300 to 600 parts per minute. The finished cores are preferably slightly undersized to allow for the additions of jackets, plates, coatings, etc. The projectile coatings, jackets, or plates can be applied, for example, electrochemical, aerosol, or mechanical methods. The jacketing material to be applied can be metallic or polymeric, as noted above. The jacketing material can be formed around the lead free projectile, or in the alternative, the jacketing material can be plated into the lead free bullet. As a final finishing operation, the projectiles can be swaged in a hydraulic press to add uniformity of appearance and exterior dimension.

The present invention provides lead free frangible projectiles from an improved composition of metals, the projectiles having a desirable combination of advantages. Specifically, the present invention provides projectiles that mimic the firing characteristics, performance, and frangibility of lead bullets without the negative health and environmental qualities associated with lead. The present invention minimizes the threat to human health associated with direct or indirect contact to airborne or residual lead particles by providing lead free projectiles. Similarly, by eliminating lead, the cleanup and disposal of the fragments of the projectiles of the present invention is safer, less expensive, and the resulting waste is not highly toxic and does not require special disposal.

While reducing the health and environmental problems associated with lead or other heavy metal projectiles, the bullets of the present invention mimic the desirable properties associated with lead projectiles. When fired they produce a recoil which is perceived by the shooter to be less than or

similar to that produced lead projectiles. The lead free bullets of the present invention also mimic the ballistic performance of lead bullets so that their respective point of impact, accuracy, and trajectory closely approximate lead projectiles. The weight of a projectile of the present invention also closely approximates the weight of a lead projectile of the same size and caliber. The projectiles of the present invention are also frangible, and upon impact with a target, disintegrate without appreciable back splatter or ricochet.

I CLAIM:

1. A lead free projectile consisting essentially of a compacted, unsintered admixture of metal particles comprising tungsten and at least one metal selected from the group consisting of iron and copper, wherein the admixture is about from 10 to 90% by weight tungsten; and wherein the particle size of each metal is about from 25 to 250 microns.

2. A projectile of Claim 1 wherein the admixture is about from 20 to 70% by weight tungsten.

3. A projectile of Claim 1 comprising about from 20 to 59% tungsten, about from 40 to 80% copper, and about from 1 to 15% iron.

4. A projectile of Claim 1 comprising about from 40 to 70% tungsten and 30 to 60% iron.

5. A projectile of Claim 1 comprising 20 to 70% tungsten and 30 to 80% copper.

6. A projectile of Claim 1 wherein the composition by weight of each metal in the admixture is about 29% tungsten, 66% copper, and 5% iron.

7. A projectile of Claim 1 wherein the particle size of each metal is at least about 100 microns.

8. A projectile of Claim 1 wherein the particle size of each metal is at least about 150 microns.

9. A projectile of Claim 1 further comprising an outer jacket.

10. A projectile of Claim 9 wherein the outer jacket consists essentially of metal.

11. A projectile of Claim 10 wherein the jacket metal is selected from the group consisting of copper, aluminum, and zinc.

12. A projectile of Claim 11 wherein the outer jacket consists essentially of copper.

13. A projectile of Claim 9 wherein the outer jacket consists essentially of polymeric material.

14. A projectile of Claim 13 wherein the polymeric material is thermoplastic.

15. A projectile of Claim 14 wherein the thermoplastic is selected from the group consisting of polyethylene, polyamide, polycarbonate, and polystyrene.

16. A projectile of Claim 13 wherein the polymeric material is a thermosetting resin.

17. A projectile of Claim 16 wherein the thermosetting resin is selected from the group consisting of phenolic, epoxy, and silicone resins.

18. A projectile of Claim 13 wherein the outer jacket consists essentially of polyethylene.

19. A projectile of Claim 1 in the configuration of a bullet.

20. A projectile of Claim 1 in the configuration of shot.

21. A projectile of Claim 1 in the configuration of a slug.

22. A process for the preparation of a lead free projectile comprising placing in a die a powdered admixture of tungsten and at least one metal selected from the group consisting of iron and copper, wherein the particle size of each metal is about from 25 to 250 microns, and compacting the admixture at a pressure of about from 50,000 to 120,000 psi.

23. A process of Claim 22 wherein the admixture is compacted at a pressure of about 100,000 psi.

24. A process of Claim 22 further comprising applying a jacketing material to the resulting projectile.

25. A process of Claim 24 wherein the jacketing material is polymeric.

26. A process of Claim 25 wherein the polymeric jacketing material is selected from the group consisting of polyethylene, polyamide, polycarbonate, or polystyrene.

27. A process of Claim 24 wherein the jacketing material is metallic.

28. A process of Claim 27 wherein the jacketing material is selected from the group consisting of copper, aluminum, and zinc.

29. A process of Claim 25 wherein the jacketing material is formed around the projectile.

30. A process of Claim 27 wherein the jacketing material is plated onto the projectile.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/19940

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F42B 8/14, 10/32
US CL :102/517
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 102/439,444,506,511,513-516,524,529

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
Search terms: tin,tungsten,iron,copper,polymeric,lead-free,polyethylene,jacket,shot,slug,resin

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,E	US 5,616,642 A (WEST ET AL) 01 April 1997, col. 3, lines 58-66; col. 4, lines 58-60.	1, 7, 8, 19, 22, 23
Y,E	US 5,597,975 A (SATOW) 28 January 1997, col. 2, lines 25-30.	30
Y,P	US 5,527,376 A (AMICK ET AL) 18 June 1996, col. 2, lines 57-61.	5, 20
Y	US 5,399,187 A (MRAVIC ET AL) 21 March 1995, col. 5, lines 10-65; col. 6, lines 13-15.	1, 2, 4, 9-11, 13-17, 19, 22-29
Y	US 5,375,529 A (KNIGHT, JR ET ALI) 27 December 1994, Fig. 4, col.4, lines 5-15, 42-51.	1, 2, 9-15, 19, 24-29

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2,278,423 A (SLATER ET AL) 30 November 1994, page 2, line 22 - page 3, line 16.	1, 7-15, 19, 21, 22, 24-29
Y	US 4,949,645 A (HAYWARD ET AL) 21 August 1990, col. 2, lines 9-30, col. 3, lines 47-55, col. 8, lines 12-45.	1, 2, 4, 5, 7, 8, 16, 17, 20, 22
Y	US 3,570,406 A (FREY ET AL) 16 March 1971, col. 2, lines 49-53.	13, 14, 18